Transmission channels matter: Identifying spillovers from FDI

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FDI and Productivity Spillovers in Sub-Saharan Africa: Identifying the Transmission Channels

1. Introduction

The object of this paper is to analyse the productivity spillover effects of foreign direct investment (FDI) by explicitly separating the various transmission channels through which they may occur, as well as taking into account firm heterogeneity. We do this for a number of sub-Saharan economies utilising a unique firm level data set. Our analysis permits a considerably more nuanced approach to evaluating the potential productivity spillovers of FDI, as are able to disentangle which spillover transmission effects work, and under what particular circumstances. To the best of our knowledge, our analysis is the first empirical analysis that examines the different channels through which productivity spillovers of FDI can occur in the developing country context, also taking into account the differing ability of local firms to benefit from productivity spillovers.

Foreign direct investment (FDI) is not only regarded as the *sine qua non* for growth strategies in developing countries, but there is also broad agreement that FDI improves the productivity of domestic firms. When foreign firms invest in a host country, they often bring with them their proprietary technology (Dunning, 1981; Mebratie and Bedi, 2013). Based on the assumption that local firms will be able to benefit from this knowledge transfer, many governments carried out policies that encourage FDI by offering extensive financial incentives (Aitken and Harrison, 1999; Ajakaiye and Page, 2012; Merlevede *et al.*, 2014).

The literature distinguishes between two groups of FDI spillover effects: knowledge spillovers and allocative efficiency spillovers. Knowledge spillovers occur via skilled *labor mobility* and also where it *demonstrates* the feasibility or enables the *imitation* of new technologies. Allocative efficiency spillovers arise from the *competitive* pressures to improve local efficiency using existing technology and resources more efficiently or even bringing new technology. This defines the three theoretically posited transmission channels of intra-industry productivity spillovers: worker mobility, imitation and competition effects. Unfortunately, there is a gap between the theoretical propositions and their empirical application.

The evidence on the actual productivity spillovers of FDI is mixed. We systematically reviewed 74 empirical studies providing 1,545 estimated spillovers conducted by 96 researchers for 31 developing countries published over 1983-2013. The list of studies systematically reviewed are provided in Table A1. Research on FDI spillovers lead to inconsistent results that continue to be disputed in the literature. The results suggest only about one-third of the cases find significantly positive productivity gains, whereas one in six find significantly negative effects. Approximately, 51% report either positive or negative, but insignificant, spillover effects. In spite of the policy relevance in promoting FDI and the burgeoning of this literature, the empirical evidence provides diverging results.

However, the available 74 empirical studies merely investigate spillover effects in terms of whether productivity of local firms is affected by FDI presence. Spillover effects

are commonly investigated in a framework of a production function. Productivity of domestic firms is regressed on various explanatory variables that introduce one spillover variable in terms of foreign share alone in a given industry. Equity, employment, and output or sales of the foreign share are three measures of FDI presence.[1] Only one of these three variables is used to interpret the effect of FDI presence.

Accordingly, existing studies have not investigated the transmission channels through which the productivity spillovers are expected to emerge. This is because the three measures of FDI presence mentioned above mainly capture the effects of demonstration or contagion spillover type (Kokko, 1996; Hamida, 2013). They cannot explain spillovers that are determined by worker mobility (Hamida, 2013) and competition effects (Kokko, 1996). In fact, the theoretical model by Wang and Blomström (1992) indicate spillovers from competition are not necessarily determined by the share of FDI presence alone, but rather mainly by the interaction between domestic and foreign firms. Tian (2007) also suggests the share of foreign presence offers only a partial picture of spillover effects. Therefore, the implicit assumption of the FDI share alone providing the overall spillover effect can be misleading as it disregards certain transmission channels. Furthermore, the treatment of the foreign share alone may result in biased estimates, as the error term will consist partly of the non-included spillover channels.

Set against this background, the present article hypothesizes that the share of FDI presence alone cannot represent the complete picture of intra-industry productivity spillover effects. To do so, we allow the FDI spillover effects to vary according to various transmission channels mentioned above, hence bridging the gap between theoretical perspectives and their empirical implementation. We also take into account the nature of firm-level heterogeneity as local firms will differ in their ability (absorptive capacity and technological levels) to benefit from productivity spillovers from foreign firms. The empirical literature largely ignores the heterogeneity of both absorptive capacity and the technological levels of domestic firms (only 10% of the studies reviewed control for these factors).We are interested in using Sub-Saharan Africa (SSA), as these countries are under-represented in the empirical investigation of the 74 empirical studies reviewed by us.

The rest of the work is organized as follows: Section 2 summarizes the theoretical perspectives on transmission channels and firm-level heterogeneity, setting out hypotheses to be examined. Section 3 discusses the data and empirical approach used. Section 4 gives the detailed results, and section 5 concludes.

2. The Framework: Theoretical Perspectives and Hypotheses Formulation

This section first discusses the theoretical perspective of the spillover channels to set out a framework for the analysis. Next, it highlights the firm-level heterogeneity related to absorptive capacity and technology level. Finally, it highlights the importance of geographical proximity and ownership structure. In each sub-section, we set out testable hypotheses.

[1] Approximately, 18% of the studies reviewed use the foreign share in equity, 35% the foreign share in employment and 47% the foreign share in output or sales.

2.1. FDI spillovers and transmission channels

The FDI-induced intra-industry productivity spillover effects are understood to occur via three channels: imitation, worker mobility, and competition effects. The theoretical channels distinguish the nature of spillover effects into technological and pecuniary spillovers. The former operates through the direct effect on production process caused by the flow of knowledge from one firm to another firm that is not captured by the market mechanism (Papandreou, 1994). While, the latter may result from an indirect effect driven by the market mechanism (Scitovsky, 1954).

First, the imitation/demonstration channel is probably the most typical technological spillover assumed to occur through the non-market mechanism (Blomström and Kokko, 1998). The imitation of new products and processes provided by FDI to the host market is assumed to speed up access and utilization of technologies by domestic firms (Ajakaiye and Page, 2012). The argument hypothesizes that exposure to superior technology of foreign affiliates can lead to productivity or efficiency gains for local firms through enhancing their production methods.

Secondly, the worker mobility channel works through pecuniary or technological spillovers. On the one hand, technological spillovers occur when a domestic firm hires workers having previously worked for or trained by foreign affiliates, allowing a domestic firm to benefit from the experience and knowledge acquired in the foreign firms (Saggi, 2002). Technological spillovers also emerge when locals previously working for foreign subsidiaries setup their own business. On the other hand, foreign firms may attract skilled local workers by paying higher wages than domestic firms. The wage differentials between foreign and domestic firms can generate pecuniary spillovers in two ways. First, the additional experience and knowledge acquired by local workers while working for foreign affiliates might be available to the domestic firms at a price equivalent to this wage premium. Second, the presence of a higher wage may put upward pressure on the overall industry wage rate, resulting in a negative effect on profits of the domestic firms. These may compel domestic firms to be more efficient, thereby generating positive pecuniary spillovers, as it occurs through the market mechanism.

Thirdly, the competition channel is postulated to emerge through the market mechanism, yielding pecuniary spillovers. Competition in the local market can be interpreted as an incentive for domestic firms to use existing technology and resources more efficiently or even adopt new technology, generating positive pecuniary spillovers, whereas, negative pecuniary spillovers may result from the existence of a market loss effect. Foreign firms may lower the market share of domestic firms by taking part of the local market. Furthermore, if domestic firms are unable to compete, foreign firms may push them out of the local market; a crowding out effect.

Over the last four decades, a wide ranging literature has developed the theoretical concept of spillover effects. Too often, existing theoretical models do not offer a complete picture of the channels outlined above. In the theoretical models of Koizumi and Kopecky (1977), Findlay (1978) and Das (1987), spillovers are determined by the foreign share alone - the imitation-determined or contagion-spillovers type. Whereas, in Wang and Blomström (1992), spillovers are assumed to emerge endogenously resulting from the technological competition between foreign and local firms - the competition-determined spillovers. Moreover, in the Kaufmann (1997), Fosfuri *et al.* (2001), and Glass and Saggi (2002) studies, spillovers are expected to occur through the movement of workers from

foreign affiliates - worker mobility-determined spillovers. Accordingly, we believe that the three types of spillovers should be combined in a single estimation to gauge a picture of the overall spillover effects. Hence, our main hypothesis is as follows:

Hypothesis 1: The occurrence, sign and size of spillover effects vary with respect to the channels through which they emerge.

2.2. Spillover Channels and Firm-level Heterogeneity

Firms differ in terms of their technological competence and absorptive capacity (Hamida, 2013). In this case, spillovers may not emerge evenly across firms, or be equally valuable to all firms (Merlevede *et al.*, 2014). However, most studies attempted to test spillover effects regardless of the nature of firm-level heterogeneity (Demena and Bergeijk, 2016). The empirical design of existing studies recognize the importance of factor input and its quality, but fail to include some important firm-level heterogeneity. For instance, about 90% of the specifications do not consider the technological levels and absorptive capacity of the domestic firms, a point already stressed by Mebratie and Bergeijk (2013) regarding absorptive capacity.

2.2.1. Spillover Channels and Technological level

With regard to technological levels, there are two opposing arguments based on economic theory. One group hypothesizes that a large technology gap, and a low technology level of the host country increases the likelihood of spillover gains. The original model of technology spillovers by Findlay (1978), and another by Wang and Blomström (1992), put forward the catch-up hypothesis: a positive relationship between the size of technological gap and the likelihood of spillovers. The original speculative thinkers of this viewpoint are Veblen (1915), followed by Gerschenkron (1962) known as Veblen-Gerschenkron (VG) effect.[2] The other group theorizes that smaller technology gaps may lead to potential spillover benefits (Lapan and Bardhan, 1973; Cohen and Levinthal, 1989). This group maintains the technology accumulation hypothesis, that is, a similar technological level between local and foreign technology results in larger spillover effects. Hence, a certain technological level seems to be important for spillover benefits.

According to Mody (1989), firms that are characterized by a relatively high technology, but with a small technological gap with the foreign firm, have a greater capacity to gain from FDI via imitation and/or competition channels. Firms in the low technological group may unable to gain via these channels as such firms lack sufficient levels of human capital that enable them to exploit available foreign technologies. Firms in low technological group may rather benefit from spillovers through the worker mobility channel as this channel can provide technical assistance that allow them to better understand and use available foreign technology (Hamida, 2013). Accordingly, our next hypothesis is:

Hypothesis 2: Technological gaps are relevant in SSA for the spillover channels and benefits largely firms with smaller technological difference vis-à-vis foreign counterparts.

[2] Specifically, this theoretical assumption suggests that faster technological transfer takes place with relatively greater technological disparity.

2.2.2. Spillover Channels and Absorptive Capacity

With regard to absorptive capacity, spillovers are hypothesized to depend on the existing capacity of domestic firms to efficiently exploit external sources of knowledge (Narula and Marin, 2003). The concept of absorptive capacity includes the ability of a firm to internalize the value of new external information, modify it to fit into their own application, and process it productively (Cohen and Levinthal, 1990). In this case, absorptive capacity is not purely about imitation. This is because, firms cannot reap the benefit of external knowledge unless they invest in their own absorptive capacity, as the knowledge can be specific to the originating firm (Narula and Marin, 2003). Consequently, the ability to assimilate and use external sources of information is highly related to the level of firm's prior knowledge. The occurrence and extent of potential spillover effects in turn may depend on these collective firms' abilities, known as absorptive capacity.

Accordingly, high absorptive capacity firms can benefit more from spillovers via imitation and/or competition channels, as such firms invest in the quality of their human capital. This would allow them to obtain specific foreign techniques through both the implementation of foreign technologies and the development of existing ones (Hamida, 2013). Conversely, firms with low absorptive capacity may only benefit through imitation effects, as these firms may not possess the required skilled human capital that would help them to cope and compete with foreign rivals. Hence, our third hypothesis is:

Hypothesis 3: The workings and size of the spillover channels is larger for SSA firms that invest in building their absorptive capacity.

2.3. Spillover Channels and Geographic Proximity

The workings of the spillover channels are also associated with geographical proximity (Girma, 2005; Jordaan, 2005). More specifically, Girma (2005) summarizes three main reasons for geographical dimension of the channels. First, imitation effects at least initially benefit physically proximate domestic firms or ones that operate in the same region as foreign firms. The imitation of production of a new product or an efficient production of existing product is more likely to take place when both firms are located in proximity (Jordaan, 2005). Second, labor mobility is likely to be confined to the same locality. Third, the theory of economic geography indicates that the potential for spillovers are more pronounced when both types of firms are within geographic proximity. Jordaan (2005) adds that the imitation and worker mobility channels are likely to generate positive spillovers when the two types of firms are geographically co-located, whereas the competition channel is ambiguous as proximity enhances both the occurrence of negative and positive pecuniary spillovers.

Furthermore, in SSA, foreign investment projects tend to concentrate in larger and capital cities where financial, infrastructural, human capital and institution systems are well developed (Kinda, 2013). This provides a better geographical proximity between domestic firms and foreign rivals that in turn may enhance the flow of information. Hence, our fourth hypothesis follows:

Hypothesis 4: Proximity matters for the workings of the spillover channels.

2.4. Spillover Channels and Ownership Structure

With regard to ownership structure, a recent study by Müller and Schnitzer (2006) hypothesizes spillover effects to vary with the degree of foreign ownership. Similarly, Takii (2005) argues majority ownership enhances transfer of advanced foreign technology in the host country, and thus the potential for spillovers but may impede the extent of potential leakage. Conversely, a higher local participation as in the case of minority foreign subsidiaries provides the opportunity to become acquainted with foreign advanced technology, as this allows better access to specific foreign knowledge that enhance spillovers (Blomström and Sjöholm, 1999). However, the incentive to transfer new technology on the part of the foreign subsidiaries may diminish with a higher local shared ownership (Crespo and Fontoura, 2007). In this regard, foreign subsidiaries may prefer a higher majority ownership to protect the extent of firm-specific knowledge and technology leakages. However, Takii (2005) further argues that foreign subsidiaries may not sufficiently control the extent of knowledge and technology leakages. If so, the occurrence and extent of spillovers is likely to come about from majority than minority foreign subsidiaries. The fear of technology leakages on the part of the latter type may not transfer advanced technology from the parent company. Hence, our last hypothesis:

Hypothesis 5: The occurrence and size of spillover effects is mainly driven by the majority-foreign-owned firms in SSA.

The theoretical perspectives discussed above have various implications for empirical investigation. For instance, too often the empirical examination of the relative importance of the labor mobility channel (in terms of either technological or pecuniary spillovers) is difficult to investigate as it requires tracking workers employed or trained by foreign firms and also those who setup their own business. Furthermore, the literature is largely confined to formulating a linear form relationship between productivity gains and FDI. This is mainly due to the theoretical expectation that spillovers are largely dependent on the extent of foreign ownership alone (see Koizumi and Kopecky, 1977). However, the relationship can also be non-linear in that spillovers might increase, and then decline beyond a certain point.

3. Data and Empirical Approach

3.1. Data Construction and Descriptive Analysis

We construct firm-level panel data obtained from separate panel datasets of the World Bank's Regional Programme on Enterprise Development. The World Bank enterprise surveys are designed to provide longitudinal datasets through a stratified sampling approach (World Bank, 2014). The top priority of the surveys is to provide rich datasets to investigate changes in business environment that affect productivity at the firm level both over time and across countries. The Surveys cover the non-agricultural formal private sector and employ the same sampling methodology and survey instruments across all countries using three levels of stratification, namely, region, sector and firm size.[3]

[3] For a thorough presentation of sampling: http://www.enterprisesurveys.org/methodology

Business sectors are defined in accordance with the International Standard Industrial Classification (ISIC) Rev. 3.1 2-digit classification.[4]

As illustrated in Table 1, based on data availability, we construct data from eight SSA countries (Congo Democratic Republic, Ghana, Kenya, Malawi, Senegal, Tanzania, Uganda and Zambia) spanning the period 2006–2014. The standardized sampling strategy and questionnaire enabled us to construct a dataset of the aforementioned SSA countries. Although the dataset comprises 8,801 foreign and domestic firms, our investigation is restricted to 1,590 firms, as the empirical strategy requires a panel data analysis. Of the panel sample, about 85% are domestic firms. In terms of the number of establishments interviewed in each SSA country of the panel sample, Senegal represents the highest sample size: 30% of the total panel sample. In contrast, Tanzania and Ghana are the countries with lowest sample size of the interviewed firms: respectively, three and four percent of the total panel sample. The other SSA countries represent approximately a similar sample distribution of 10-19%.

<Insert Table 1 about here>

Table 2 presents the ownership distribution of the firms. These surveys comprise firm-level information for 8,801 in both surveys of the data (3,632 in the first wave/2006 and 5,169 in the second wave/2014). In 2006, 3,632 firms were interviewed, but only 795 again in 2014. Thus, 2,837 firms were surveyed only in 2006 and 4,374 firms were surveyed only in 2014. Of the 4,374 firms surveyed only in 2014, 72.9% (3,188) of the firms commenced operations before 2006. So that a large number of firms started operation before 2006 but were not included in the 2006 survey.

<Insert Table 2 about here>

Another concern is whether the 2,837 firms interviewed only in 2006 and not included in 2014 were excluded due to exit from their industry or because of other systematic or non-systematic random factors. If firms that drop out differ systematically from firms that continue, then the information from the continuing firms is no longer representative of the whole sample. In that case, we examine whether the attrition is systematically associated with firm characteristics or is entirely random. We provide an attrition probit model where the dependent variable takes the value 1 for firms which dropout after the first wave and 0 otherwise. Results of the attrition probit are provided in Table A2. The probit regression indicates that attritted firms are not systematically different from retained firms at any conventional level, as none of the firm characteristics is statistically significant.

Tables 3 and 4 list summary statistics, and Table A3 gives the definition of the variables. The commonly stylized facts found in the literature of FDI spillovers are also confirmed in our sample of panel data. Foreign-owned firms tend to be more productive,

[4] For a detailed discussion of the ISIC: http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=17

with greater employment and formal training provision, operate for a longer period, are more adept at exporting, and have a higher technological level. Another key difference is the size of technological gap. While the bulk of the domestic firms (77%) fall in the category of large technological gap, only 43% of the foreign firms fall into this category. Foreign firms on average have 138 workers as compared to 42 workers for domestic firms. All these differences are statistically significant at 1%. Moreover, foreign firms are likely to have operated for a longer period (on average 20 years). In terms of firm size, foreign firms appear to fall approximately equally in all the three categories. In sharp contrast, the bulk of domestic firms (67%) fall into the category of small-sized firm. However, exceptionally both domestic and foreign firms are likely to be similarly endowed in terms of capital intensity.

<Insert Table 3 about here>

Table 4 offers an idea about summary statistics for the spillover channels. The statistics are based on a clustered analysis of 8 countries and 26 industries[5]. The statistics show that the majority-foreign-owned firms mainly explain the spillover variables. This is also consistent with the competition channel that shows a lower mean value for majority-owned firms. This is because competition in the local market is calculated as the difference between sales and costs over total sales so that a value close to 0 indicates heightened competition, with firms' prices close to costs (Narula and Marin, 2003). This indicates the existence of high competition within majority as opposed to minority-foreign-owned firms.

<Insert Table 4 about here>

In order to standardize the data, we converted all data from local currency units into U.S. dollars and deflated them using gross domestic product (GDP) deflator (i.e., in U.S dollars with 2000 as the base year).[6]

3.2. Empirical Approach

We design a model of spillover effects within the context of a production framework in which output is a function of capital, labor and access to technology. With regard to the outcome variable, the empirical literature uses a production function of either a one-step

[5] For the list of the industries (A.4 Industry Questionnaire – it contains 27 industries. However, the datasets for SSA do not contain information about recycling, ISIC 37): http://www.enterprisesurveys.org/~/media/GIAWB/EnterpriseSurveys/Documents/Methodology/ES_Manufacturing_Questionnaire.pdf

[6] We have obtained all data related to exchange rates and GDP deflators from the World Development Indicators - http://data.worldbank.org/data-catalog/world-development-indicators.

direct approach (see Aitken and Harrison, 1999; Hamida, 2013, Mebratie and Bedi, 2013), or a two-step indirect estimation technique (see Waldkirch and Ofosu, 2010; Merlevede *et al.*, 2014). The former employs a direct approach of the FDI effect using labor productivity, output or value-added as the dependent variable. Whereas the latter uses an indirect approach of total factor productivity. We note that there is no consensus on the appropriateness of the one-step versus the two-step approach. However, a recent meta-analysis suggests a one-step approach given that this literature has been influenced by a selection bias towards positive estimates (Demena and Bergeijk, 2016). Hence, we opted for a direct approach of labor productivity.[7]

Our baseline equation is:

$$\ln(LP_{ijt}) = \beta_0 + \beta_1 T_t + \beta_2 I_j + \beta_3 C_x + \beta_4 FDI_{ijt} + \beta_5 FDIs_{jt} + \beta_6 AC_{ijt} + \beta_7 TG_{ijt} + \alpha \sum X_{ijt} + \varepsilon_{ijt} \quad \text{.....(1)}$$

The subscripts *i*, *j*, and *t*, represent firm, industry and time respectively. The inclusion of time dummy (T_t) accounts for any possible regional trends and economic events. Likewise, the inclusion of industries fixed effects (I_x) accounts for unobservable time-invariant effects that may drive changes in labor productivity, for instance, attractiveness of a particular industry. A full set of countries fixed effects is included to account for unobservable time-invariant heterogeneity in countries, for instance, attractiveness of a particular country (e.g., better infrastructural presence). Accordingly, the inclusion of time dummy, country and industry fixed effects addresses the econometric concerns of omission of unobserved variables that may breakdown the exogeneity condition relevant to obtaining unbiased and consistent estimates.

Unlike existing studies where $FDIs_{jt}$ is measured through foreign share alone, this study disaggregates spillover measures into the abovementioned three channels. First, the imitation effects measured as the share of total sales accounted by foreign firms (see Hamida, 2013). The imitation effect works via the direct contact between local and foreign firms. This effect captures the knowledge of processes and products available in the domestic market by foreign firms. After observing a new product or process innovation and also allowing for their feasibility, domestic firms may strive to copy and use it (Meyer, 2004; Crespo and Fontoura, 2007).

Second, the worker mobility channel measured with the interaction term between foreign presence and human capital in terms of domestic employees (see Meyer and Sinani, 2002, 2004; Hamida, 2013). This variable is assumed to measure the combined effect of the presence of foreign share in the industry and the level of human capital at the domestic firm level on the productivity of the domestic firm. This interaction investigates the worker mobility-determined spillover in the domestic market that is supposed to be co-determined by the interaction of these two variables.

Third, following Chung (2001) and Narula and Marin (2003), the competition effects measured by firm's price markup. We use the differences between a firm's total sales and costs over total sales to measure price markup. The firm level price markup is an

[7] McKenzie (2011) indicates labor productivity is important for generating long-run growth and creating job opportunities for the young and growing African labor force. Buckley *et al.* (2007a) and Mahmood (2008) also point out that the use of labor productivity is an appropriate outcome variable, as it has potential importance in improving the living standard and wages in the domestic economy.

appropriate measure of the level of competition (Hamida, 2013). When the price markup is close to 1 or there is a high markup, competition is low. Conversely, when it is close to 0, competition is higher. A decrease in the markup is therefore heightened competition. This follows a negative coefficient associated with a decrease in the markup (increased competition), followed by an improvement in domestic productivity (Chung, 2001).

To test for a curvilinear spillover effect, we include squared terms of the three spillover variables in Eqn. 1. We also include a set of control variables (X_{ijt}) WHAT ARE THEY???, measure of foreign ownership (FDI_{ijt}), absorptive capacity (AC_{ijt}), and the technological gap (TG_{ijt}) outlined in Table A3 and the time-variant error term (ε_{ijt}). With regard to technological gap, we use the ratio of average productivity of foreign-owned firms to domestic firms own productivity in a given industry and country (see Haddad and Harrison, 1993; Haskel *et al.*, 2007). To split our sample into small and large technological gap, we use a dummy variable that takes the value 1 if domestic firm productivity is below the average productivity of foreign firm and 0 otherwise (see Jordaan, 2005; Hamida, 2013). When a dummy is 1, the gap is high, whereas when a dummy is 0, the gap is small. For absorptive capacity, we use a dummy variable that takes the value 1 when a domestic firm provides formal training programs for its employees and 0 otherwise. Although recently Chung and Lee (2015) report absorptive capacity measured through its origin, i.e., licensing of foreign technologies but they do acknowledge the importance of on-the-job training programs as an alternative way to build absorptive capacity.[8]

In terms of empirical estimation, given the two-period panel data, we performed a set of econometric tests to provide better estimations. First, we adopt the Breusch-Pagan Langrange multiplier (BP-LM) test. The BP-LM tests allows us to reject the null hypothesis that the pooled OLS method is efficient in favor of the random-effects model. Next, we apply the Hausman test that suggests that the random-effects model is not appropriate, indicating the appropriateness of fixed-effects estimation.

Following the empirical strategy outlined above, several concerns are addressed in terms of econometric issues. First, the omission of unobserved variables. We address this issue by including time-invariant fixed effects as well as a time dummy and a set of time-variant firm-level variables. Second, concerns related to endogeneity or potential selection bias. For instance, if a foreign firm gravitates into the most productive industry, then the observed result of productivity spillovers will overstate the impact from FDI. The best way to address this possibility is to estimate fixed-effects (Konings, 2001; Hanousek *et al.*, 2011; Mebratie and Bedi, 2013). In addition to the usual methods of econometrics of panel data, estimation of fixed-effects is, therefore, likely to mitigate the possibility of reverse causality from domestic productivity to foreign investment. Third, we conduct further analysis and a set of several robustness checks for the sensitivity of our results as well for any possible measurement errors, through alternative specifications. All of these empirical approaches address econometric concerns that may have biased the estimates of previous research. Importantly, we adopt a set of lessons from a recent meta-analysis (Demena and Bergeijk, 2016).

[8] Our data do not contain variables that would adequately capture licensing of foreign technologies.

4. Estimation Results and Discussion

4.1. Spillover Transmission Channels

A set of different estimations are presented in this section. We start with whether the three spillover channels should be included separately or simultaneously in Eqn. 1. The Wald test justifies the simultaneous estimation of the channels at 1% statistical significance level. To better visualize the results and keep the table manageable, we report only results relating to the transmission channels.

<Insert Table 5 about here>

Table 5 gives the results from the fixed-effects model testing our first hypothesis.[9] We report the estimated effect of both linear and curvilinear models of Eqn. 1. We conduct the Akaike's information criterion (AIC) to determine between linear and curvilinear specifications. The AIC supports the curvilinear specification as lower AIC implies little information loss in the model.[10] Indeed, the existence of a significant competition effect in the curvilinear specification alone is adequate to reject the linear model.

Estimation of our preferred curvilinear specification (Panel A2) gives significant imitation and competition effects. The imitation channel indicates FDI creates positive spillover influences on domestic productivity. More specifically, a 10% point increase in foreign presence is associated with an 18% increase in labor productivity of domestic firms, indicating the presence of technological spillovers. The findings supports the theoretical position that foreign affiliates speed up the access and transfer of new product and process in the host economies (Wang and Blomström, 1992; Meyer, 2004).

The competition channel that points to the non-linear specification show that an increase in competition generated by FDI presence enhances the productivity of domestic firms. This indicates the presence of positive and significant pecuniary spillovers. The relatively low estimated effect size of the C^2 (which is not different from zero), as compared to C, shows decreasing spillover effects when the level of competition goes beyond a certain point due to an increase in FDI presence. This means that spillovers demonstrate the presence of a non-monotonic relationship with FDI presence, where the positive effects are dominant when there is low or moderate foreign presence, and exceeding some level of increased foreign presence, spillover effects begin to decrease. This might indicate the existence of market-steal/loss effects when the level of competition due to an increase in FDI penetration is past a certain point.

Results of Panel A, therefore, corroborate our first hypothesis that the occurrence, sign and size of spillover effects vary with respect to the channels through which they

[9] Due to some missing data for the technological gap, markup, labor productivity and absorptive capacity variables, the regression uses a sample of only 1,576.

[10] We also conduct *F-tests* that suggest the curvilinear specification is better compared to the linear one at 1% significance level.

emerge. This important finding may help to explain why the resulting estimates using the share of foreign presence alone cannot describe the whole picture of spillover effects. In this regard, it is appropriate to investigate the three spillover channels simultaneously in order to capture the overall influence of FDI. Next, our study goes further to separate domestic firms according to technological levels and absorptive capacity.

4.2. Spillover and Technological Level of Domestic Firms

We estimate two separate regressions for our measure of technological gap. Table 6 gives the results testing the second hypothesis. Panel B1-B2 and Panel C3-C4 present the results for small and large technological gaps, respectively. Again, we conduct the AIC for linear versus curvilinear specifications and the results suggest better fit of the curvilinear specifications (B2 and C4) in both the small and large technological gap groups.

<Insert Table 6 about here>

Our main findings seem to confirm that spillovers are a positive function of the level of technology. Higher technological domestic firms seem to experience significant positive spillover effects from the imitation channels (Panel B versus Panel C). That is, firms with small technological gap are better to identify and exploit the introduction of new technological opportunities into a local market associated with the presence of FDI. This can be an indication that these firms are not far from the average technological frontier of a given industry and have sufficient scope for potential imitation-determined spillovers. In contrast, relatively large technological gap domestic firms seem to be hit significantly by the presence of foreign counterparts, or fail to reap spillover benefits from imitation. This may suggests the presence of a reverse spilling-over effect.

With regard to labor mobility, it is positive and significant for the large technological gap group, indicating that the combined effect of foreign presence and local human capital results in an increase in domestic productivity. This confirms the results of Hamida (2013) in that such firms can benefit greatly via the worker mobility channel, as this can contribute to technical assistance that can allow such firms to better understand and use foreign technologies.

C becomes significant for both technological groups, but negative for small gap firms and positive for large gap firms, indicating the presence of pecuniary spillovers. Small technological gap firms appear to benefit spillovers through the competition channel as a decreased markup (heightened competition) is followed by an increase in productivity. In contrast, large technological gap firms seem unable to cope with the competition from foreign presence, suggesting the occurrence of market-steal/loss effects. C^2 is positive and significant for small technological gap firms, demonstrating that the benefits from competition effects emerge when the level of foreign presence is lower or moderate. Once foreign presence goes past some level, pecuniary spillovers start to fall as intense competition creates market-losing effects, implying a curvilinear relationship. This confirms theoretical expectations that a high-level of foreign presence intensifies competition that even hurts the relatively high technological firms. The findings also confirm what we discover for the full sample in Table 5 where the high technology firms

appear to dominate spillover benefits. This corroborates our second hypothesis that the workings of the channels and the size of the effects vary according to domestic technological levels. The benefit is much larger for SSA firms with smaller technological differences vis-à-vis their foreign counterparts. Large technological gap firms appear to benefit from spillovers only through the labor mobility channel. This group of firms is better to invest in hiring local workers who have worked for or were trained by foreign affiliates by offering a higher wage as long as the marginal benefit of recruiting is larger than its marginal cost in order to offset the market-losing effects from the competition channel.

Our evidence is contrary to the original theoretical formulation of VG effects (and Findlay, 1978) that indicate technological effects will takes place faster when there is a greater relative technological gap between domestic and foreign firms. This was the basic theoretical assumption behind a number of developing country policies attempting to attract FDI in high technology sectors (Fan, 2002). By contrast, our evidence indicates that this was not a valid assumption. Rather, SSA's domestic firm productivity appears to benefit from foreign entry when the technological gap is smaller, supporting the theoretical assumption of Lapan and Bardhan (1973), among others.

4.3. Spillover and Absorptive Capacity of Domestic Firms

Table 7 gives results of the spillover channels that vary in terms of absorptive capacity testing the third hypothesis. Again, we conduct the AIC and find the linear specification is superior to the curvilinear one for the high absorptive group. However, for the low absorptive group the curvilinear specification is preferable to the linear specification.[11]

<Insert Table 7 about here>

With regard to the imitation channel, it appears that domestic firms in both groups (low and high absorptive capacity) internalize spillover gains. This suggests that firms in the low absorptive capacity group are also apt to understand and imitate foreign knowledge. This can be inconsistent with some existing findings. For instance, Kathuria (2001) reports significant positive effects for Indian manufacturing firms with only relatively high absorptive capacity. Note that this result is not with respect to the channels, rather only using the share of foreign presence alone.

Furthermore, *C* is significant for both groups of firms but the estimated effect size is not different from zero for low absorptive capacity firms, suggesting industries in the latter group do not seem to internalize spillover benefits through competition effects (D2 versus E3). Hamida (2013) highlights the competitive pressure generated by foreign

[11] Indeed, the inclusion of squared terms (full model) for low absorptive group result in significant *C* and C^2 with indistinguishable from zero effects and thus do not contribute any additional information. In contrast, for high absorptive capacity firms LM^2 and C^2 are significant, indicating an increase in spillover effects when the level of labor movement (i.e., the combined effect of foreign presence and local human capital) and competition beyond a certain point due to an increase in FDI presence. However, in the latter case the AIC suggests a significantly better fit of the linear than the curvilinear specification.

presence encouraging domestic firms with high absorptive capacity to work harder to exploit existing resources and technology more efficiently to improve productivity via competition effects. In line with this, a negative and significant *C* implies that a decreased markup (heightened competition) is followed by an increase in domestic productivity, i.e., positive pecuniary spillover effects.

Again, the findings are consistent with estimated effects of the full sample, in that the high absorptive group corroborates the corresponding spillover effects observed in the full sample. Firms with high absorptive capacity attempt to gain spillover benefits through both the imitation and competition channels. The ability of these kinds of firms to absorb foreign technologies is largely determined by the quality of their human capital as these firms invest in training their employees that allow them to acquire specific foreign technologies. The findings confirms that high absorptive capacity firms are able to cope and fiercely compete with foreign counterparts that induce them to use their existing technology and resources more efficiently and imitate advanced foreign technologies. Results are in line with the absorptive capacity hypothesis and empirical results of Kathuria (2001), Narula and Marin (2003) and Hamida (2013).

4.4. Further Investigations and Robustness Checks

In this section, we look into further analyses to test the remaining (fourth and fifth) hypotheses and several robustness checks related to our findings outlined above. The former deals with the question of ownership structure and geographical proximity. The latter explores the sensitivity of our findings to the: (1) construction of the spillover variables; (2) construction of the outcome variable; (3) introduction of a set of industry-time interaction dummies; and (4) estimation method.

<Insert Table 8 about here>

a) Further investigation: spillover effects and ownership structure

In Table 8, we allow the construction of spillover channels to vary in terms of minority- and majority-foreign-owned firms. We do this by dividing the previous version of foreign-ownership into two variables. In Panel F, we define majority foreign ownership with 50% or more ownership, and set to zero if foreign ownership is less than 50%. Similarly, Panel G presents the minority foreign ownership with less than 50% (but at least 10%). The AIC supports the linear specification over the curvilinear one.[12]

Our finding corroborate the view that the advanced technology of majority-foreign-owned firms mainly drives the spillover benefits. A possible explanation is that foreign investors may be more inclined to bring with them their proprietary technology when they own majority ownership control over subsidiary operations. Furthermore, majority-owned firms somewhat enhance the workings of the worker mobility channel, but impair

[12] In fact, the inclusion of squared terms (full model) for majority-owned-foreign firms does not contribute any additional information, whereas for the minority-owned-foreign firms only C^2 contributes additional information with a similar overall message.

benefit from the competition channel. The latter may suggests that although advanced technologies of majority subsidiaries offer the possibility for larger spillovers, they may impede spillovers through market-losing effects. In other words, market-losing effects of foreign presence can hamper the scope for competition-determined spillovers. An alternative explanation could be that domestic firms encounter the presence of highly negative competition effect from majority-owned firms than the minority-owned firms.

Panel G3, on the other hand, shows that minority-foreign-owned firms appear to induce spillover benefits only through the workings of the competition channel. This benefit is similar to the estimated effect of the full sample (Table 5). This suggests the minority-foreign-owned firms mainly drive the competition spillover benefits of the full sample. It is also an indication that the minority foreign investors are unwilling or unable to take along their most advanced technologies to host countries, thus causing the scope of imitation and worker mobility spillovers to be limited. This thesis is consistent with Merlevede *et al.* (2014) and supports the hypothesis that the occurrence and size of spillover effects is predominantly driven by the majority-foreign-owned firms.

b) Further investigation: spillover effects and geographic proximity

To examine geographical proximity, we provide estimates for only firms located over the eight largest and capital cities alone (Panel H in Table 9).[13] Again, we conduct the AIC that support the curvilinear specifications (H2 and I4) better fit the data than the linear one (H1 and I3). In terms of both sign and significance of the channels, H2 corroborates the corresponding estimates in A2 of Table 5 estimated across the eight SSA. The current magnitude of estimated spillover effects are much larger and the differences are statistically significant. This is in line with the notion that geographical proximity or concentration of industries enhances the magnitude of spillover effects through the workings of the imitation and competition channels.

<Insert Table 9 about here>

In line with the concentration of firms on the largest and capital cities, Grether (1999) and Jordaan (2008) provide a measure of geographical distribution of an industry. In this sense, they find positive association of labor productivity of Mexican firms and the level of geographical distribution of an industry. This indicates the importance of controlling for distribution of firms over geographical location. The level of geographical distribution of industries over the regions of the establishment of the SSA included in the dataset is captured through the variable *Gini*. Even though, the *Gini* coefficient is usually used to measure the level of income inequality, we follow Grether (1999) and Jordaan (2008) to obtain an indication of the level of distribution of industries over geographical regions. We capture the variable *Gini* using the share of a regional industry in regional total employment over the share of a national industry in national total employment. In this sense, a high *Gini* coefficient suggests a high level of geographical agglomeration of industries.

[13] These are Kinshasa (DRC), Accra (Ghana), Lilongwe (Malawi), Dar es Salaam (Tanzania), Kampala (Uganda), Lusaka (Zambia), Dakar (Senegal) and Nairobi (Kenya).

Panel I4 gives the estimates that includes the variable *Gini* to capture the level of geographical distribution of industries. First, consistent with Grether (1999) and Jordaan (2008), the *Gini* coefficient is significant. This indicates the level of geographical agglomeration of industries have a significant association with the measured labor productivity. This is in line with the notion that geographical concentration of economic activities (industries) can facilitate the existence of agglomeration economies. Specifically, this can lead to creation of better information spillovers. Second, the current estimated spillover effects corroborate the corresponding findings of Panel A2 in Table 5. This is can be an indication that the initial omission of the *Gini* variable is not causing an omitted variable bias, as the estimated spillover effects remain unaltered.

In line with theoretical predications of Girma (2005) and Jordaan (2005), the current findings indicate a larger positive spillover effects when firms geographically located in close proximity (Panel H2 versus Panel A2). The main difference is that the effectiveness vary in terms of the channels as observed in Panel H2. The labor mobility channel is more likely to generate insignificant effects. Whereas, the workings of the competition channel indicates very small magnitude but positive and statistically significant effects. However, the workings of the imitation channel is in line with the theoretical expectations of Girma (2005) and Jordaan (2005). The results support the hypothesis that geographical proximity or concentration is likely to enhance the workings of these channels, but mainly for imitation and competition effects.

c) Robustness Checks

The robustness checks using various sensitivity analyses uniformly confirm our main findings. Frist, in Table 10, Panel J, introduces the dummy instead of the share version of the spillover variables and Panel K, replaces the separate industry and time dummies with a set of industry-time interaction dummies. The curvilinear specification is preferred over the linear one for a similar reason indicated earlier. The spillover results of J2 and K4 corroborate the corresponding findings of Panel A2 in Table 5. However, unlike the estimate of Panel A2, *I* in J2 appears to generate insignificant effect.

<Insert Table 10 about here>

Next, in Table 11, Panel L[14] and Panel M, replaces the definition of our outcome variable and uses estimation of the random-effects method, respectively. Again, in both Panel L and M the curvilinear specifications are preferred. L2 uses the value added per worker rather than the sales per worker definition of labor productivity. Our main findings of spillover results are again confirmed. Generally, the results are an indication that the use of either of the definition of labor productivity does not much matter for spillover analysis. In another robustness check, Panel M4 replaces fixed-effects with random-effects in our spillover estimation method. Again, our main findings of Panel A are confirmed once more.

[14] Because of missing information, 52 domestic firms are dropped when we replace the sales per worker definition of the labour productivity with the value added per worker.

<Insert Table 11 about here>

5. Conclusion

One of the main reasons why developing country policy makers pay special attention to attracting FDI inflows is the expected valuable productivity spillover gains (Ajakaiye and Page, 2012; Buckley *et al.*, 2007b; Hamida, 2013). The substantial increase in FDI penetration in developing countries has, in turn, spawned a substantial empirical literature seeking to measure the spillover effects. This literature has mainly attempted to measure FDI-spillover effects using the foreign share alone. According to Hamida (2013), this approach captures only the effects of imitation or contagion spillovers. Tian (2007) indicates that the share of foreign presence offers only a partial picture of spillover effects, and thus cannot capture the overall effects. Kokko (1996) and Wang and Blomström (1992) argued that the competition-determined spillover effects cannot be represented by the presence of foreign share alone. Hence, the approach of foreign share cannot fully describe how spillover effects actually emerge, mainly as it disregards other channels. Correspondingly, the literature largely presumes that spillovers occur evenly across firms, for example nine in ten of the existing effects are considered to emerge irrespective of the role of absorptive capacity and technological level of domestic firms.

To overcome the existing gap, this paper allows spillover effects to vary according to various different transmission channels, and also seeks to separate domestic firms in terms of their technological level and absorptive capacity. Furthermore, we also test for linear or non-linear effects. Using an unexplored recent panel data from SSA, our results although in line with theory, yield different results to the extant empirical literature on spillovers of DI in developing countries. First, productivity gains to domestic firms depends on the specific transmission channel. In the full sample, FDI presence generates significant spillover benefits through both imitation and competition channels, but fails to do so through the labor mobility channel. The findings of the competition channel supports the curvilinear relationship signaling the occurrence of market-losing effects counteracting the initial spillover benefits when local competition due to foreign penetration is low or moderate. The magnitude of the spillover effects are larger for the imitation effect relative to the competition channel, and the difference is statistically significant as well as remaining stable across several specifications.

Secondly, a similar spillover pattern appeared for firms in the smaller technological difference group, showing that industries with high technological levels predominately contribute to the total spillover effects found for the full sample. It also implies that market-losing effects are stronger in small technological gap industries after the initial level of competition goes beyond certain points where higher foreign penetration intensifies the level of direct competition. Industries in the large technological gap class appeared to gain spillovers only through the labor mobility channel. This may be an indication that these industries can only understand and use foreign technology through this channel as this facilitates skills acquisition to implement foreign technology. The

findings do not support the VG theoretical assumption. Rather, it supports the technology accumulation hypothesis.

Thirdly, both low and high absorptive firms benefit through the imitation-determined spillovers. However, only local firms with relatively high level of absorptive capacity absorb the competition-determined spillovers. This is in line with the theory that absorption is not purely about imitation (Narula and Marin, 2003; Hamida, 2013). Instead, only firms that have invested significantly in their absorptive capacity are able to internalize the FDI spillover gains more efficiently.

Fourthly, the advanced technology of majority-foreign-owned firms, which accounts for a higher industry share in the SSA case, mainly drives the spillover benefits from the imitation and worker mobility channels. When there is a smaller foreign industry share, minority-foreign-owned firms appear to generate spillover effects only through the workings of the competition channel. Accordingly, our result suggest that majority-owned firms mainly drive the knowledge spillover, whereas minority-owned firms stimulate the allocative efficiency spillover. The latter can be an indication that minority-owned firms are unwilling or unable to bring their advanced technologies to the domestic economy as a lower degree of managerial control may reduce the incentive to transfer technology to their subsidiaries. Last, the effect of geographical proximity or concentration enhances the magnitude of spillover effects and influences the workings of the transmission channels differently. This is consistent with the notion that geographical proximity enhances the existence and magnitude of positive spillovers but is somewhat contrary to the theoretical predictions of Jordaan (2005) and Girma (2005) for the workings of both labor mobility and competition channels.

Our findings suggest that gauging FDI-related spillovers is both a complicated process and a challenging issue. Each of spillover transmission channels need to identified and delineated clearly, and the effects of each of the channels needs careful and separate investigation before any meaningful and robust conclusions about spillover effects are reached. More future efforts for other countries should explore this line of research. Future studies should also direct the investigation towards approaches that allow the channels to vary according to the length of time a foreign company has been present in host countries. Unfortunately, our dataset does not allow us to identify duration since first entry. Alongside firm-level heterogeneity, technological characteristics, varieties of mode of entry, the country or nationality of FDI source, and the motives for foreign production need future investigation.

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Tables

Table 1. Distribution of the Firms by Country and Ownership

Country	Number of Firms						% panel
	Local		Foreign		Total		
	All	Panel	All	Panel	All	Panel	
DRC	740	150	148	34	888	184	12
Ghana	1074	52	140	10	1214	62	4
Kenya	1212	146	158	20	1370	166	10
Malawi	520	121	153	53	673	174	11
Senegal	1007	457	100	19	1107	476	30
Tanzania	1055	45	87	5	1142	50	3
Uganda	1025	150	178	24	1203	174	11
Zambia	886	225	318	79	1204	304	19
Total	7519	1346	1282	244	8801	1590	100

Table 2. Distribution of the Firms According to Ownership

Surveys	Domestic		Foreign		Total	
	All	Panel	All	Panel	All	Panel
First-wave/2006	3,129	670	503	125	3,632	795
Second-wave/2014	4,393	676	779	119	5,169	795

Table 3. Summary Statistics control and outcome variables (panel)

Variable	All firms *N=1578*		Domestic firms *N=1336*		Foreign firms *N=242*		t test for two-sample difference
	Mean	SD	Mean	SD	Mean	SD	
Labor productivity	9.34	3.33	9.00	3.19	11.22	3.49	9.83
Exports	0.08	0.27	0.06	0.24	0.19	0.39	6.58
Foreign-owned	0.15	0.36	-	-	-	-	-
Firm size (5-19)	0.62	0.49	0.67	0.47	0.34	0.48	-9.77
Firm size (20-99)	0.26	0.44	0.24	0.43	0.35	0.48	3.50
Firm size (100+)	0.12	0.33	0.09	0.29	0.31	0.46	9.61

Firm age	16.65	13.41	15.96	12.83	20.46	15.79	4.85
Formal training	0.26	0.44	0.24	0.42	0.37	0.48	4.39
Technological gap	0.71	0.45	0.77	0.42	0.43	0.49	-10.85
Capital intensity	0.037	0.153	0.034	0.151	2.07	2.41	1.33
Human capital	57.0	216.4	42.2	155.3	138.6	406.0	6.49

Table 4. Summary Statistics for Spillovers Channels

Spillover Channels	**All foreign firms: *N=242***		**Majority-foreign owned: *N=188***		**Minority-foreign owned: *N=54***	
	Mean	SD	Mean	SD	Mean	SD
Demonstration	0.39	0.26	0.42	0.26	0.30	0.25
Labor mobility	32.9	0.21	41.2	72.3	3.57	19.05
Competition	0.18	4.90	0.07	5.55	0.58	0.47

Table 5. FDI-Spillover Effects according to Transmission Channels

Variable	**Panel A:**	
	Linear (1)	Curvilinear (2)
Imitation (*I*)	1.670**	1.763**
	[0.537]	[0.415]
Imitation^2 *(I^2)*	-	-1.493
		[1.690]
Labor mobility (*LM*)	0.387* [a]	0.002
	[0.194]	[0.007]
Labor mobility^2 *(LM^2)*	-	0.000 [a]
		[0.000]
Competition (*C*)	0.016* [a]	-0.082*** [a]
	[0.007]	[0.050]
Competition^2 *(C^2)*	-	-0.000***
		[0.000]
$\bar{R}^2$	0.93	0.93
F-statistics	938.44***	233.26***
AIC	1001.37	992.96
N	1,576	1,576

Notes: Results are from fixed-effects estimates. Robust standard errors in brackets are clustered at country level. * p<0.1; ** p<0.05; *** p<0.01. The dependent variable is logarithm of labor productivity of domestic firms. Regression include time, country and industry dummies. Control variables included are medium-sized firm, large-sized firm, firm age, capital intensity, exports, FDI firm, human capital, absorptive capacity, and technological gap. In order to avoid multicollinearity and ensure better estimates, all continuous variables used for interactions are centered by subtracting the full sample means (Aiken and West, 1991)[15]. [a] Coefficients and standard errors are multiplied by a thousand to make the figures easier to read.

Table 6. Technological Level and Spillovers Transmission Channels

	Panel B: Small gap	**Panel C: Large gap**

[15] For instance, the correlation between the share of foreign presence, human capital and their interaction are 0.182 and 0.765 before centering and 0.086 and 0.515 after centering, respectively.

Variable	Linear	Curvilinear	Linear	Curvilinear
	(1)	(2)	(3)	(4)
Imitation (*I*)	25.404***	29.27***	-2.043**	-1.989***
	[7.102]	[7.750]	[0.594]	[0.458]
Imitation^2 *(I^2)*	-	0.000	-	0.095
		[0.000]		[3.143]
Labor mobility (*LM*)	-0.484 [a]	-0.006	0.001**	0.002*
	[2.474]	[0.008]	[0.0004]	[0.001]
Labor mobility^2 *(LM^2)*	-	-0.002 [a]	-	0.005 [a]
		[0.007]		[0.012]
Competition (*C*)	0.044***	-0.026***	0.002***	0.015*
	[0.006]	[0.005]	[0.0001]	[0.009]
Competition^2 *(C^2)*	-	0.006***	-	0.006 [a]
		[0.0004]		[0.004]
$\bar{R}^2$	0.42	0.48	0.33	0.34
F-statistics	621.75***	24.56***	237.08***	78.06***
AIC	805.25	760.25	1998.30	1986.16
N	441	441	1,135	1,135

Notes: See Table 5.

Table 7. Absorptive Capacity and Spillovers Transmission Channels

Variable	Panel D: Low absorptive capacity		Panel E: High absorptive capacity	
	Linear	Curvilinear	Linear	Curvilinear
	(1)	(2)	(3)	(4)
Imitation (*I*)	1.734**	2.006***	1.214 **	1.341**
	[0.677]	[0.550]	[0.488]	[0.454]
Imitation^2 *(I^2)*	-	-2.798	-	0.000
		[1.971]		[0.000]
Labor mobility (*LM*)	-0.231 [a]	0.001	-0.246 [a]	-0.003*
	[0.472]	[0.001]	[0.915]	[0.002]
Labor mobility^2 *(LM^2)*	-	-0.000	-	0.005* [a]
		[0.000]		[0.003]
Competition (*C*)	0.015 [a]	-0.0008***	-0.005***	-0.058**
	[0.074]	[0.0001]	[0.001]	[0.024]
Competition^2 *(C^2)*	-	-0.000***	-	-0.088* [a]
		[0.000]		[0.038]
$\bar{R}^2$	0.94	0.94	0.96	0.96
F-statistics	63.98***	346.33***	4928.03***	5370.74***
AIC	163.97	98.09	6.62	-22.96
N	1,171	1,171	405	405

Notes: See Table 5.

Table 8. Further Investigation of FDI-Spillover Effects: ownership structure of foreign firms

	Panel F: Majority-foreign-owned firms	Panel G: Minority-foreign-owned firms

Variable	Linear	Curvilinear	Linear	Curvilinear
	(1)	(2)	(3)	(4)
Imitation (*I*)	1.575**	1.038	-0.244	-7.293
	[0.505]	[0.777]	[1.321]	[4.706]
Imitation^2 *(I^2)*	-	-2.302	-	19.802
		[1.544]		[12.809]
Labor mobility (*LM*)	0.481* [a]	0.001	0.003	0.004
	[0.229]	[0.001]	[0.007]	[0.018]
Labor mobility^2 *(LM^2)*	-	0.000	-	-0.034 [a]
		[0.000]		[0.228]
Competition (*C*)	0.002**	-0.004	-0.359*	-0.325*
	[0.004]	[0.038]	[0.178]	[0.147]
Competition^2 *(C^2)*	-	0.089 [a]	-	-0.123*
		[5.470]		[0.043]
$\bar{R}^2$	0.93	0.93	0.93	0.93
F-statistics	287.70***	304.96***	270.56***	314.78***
AIC	1003.81	1008.17	1031.38	1048.24
N	1,576	1,576	1,576	1,576

Notes: See Table 5.

Table 9. Further Investigation of FDI-Spillover Effects: regional distribution of firms

Variable	Panel H: Mainly concentrated city/region		Panel I: geographical dispersion: full sample	
	Linear	Curvilinear	Linear	Curvilinear
	(1)	(2)	(3)	(4)
Imitation (*I*)	4.124***	4.160***	1.686**	1.790***
	[0.939]	[0.800]	[0.539]	[0.406]
Imitation^2 *(I^2)*	-	-0.352	-	-1.592
		[1.239]		[1.708]
Labor mobility (*LM*)	0.0006**	0.068 [a]	0.384* [a]	0.225 [a]
	[0.0002]	[1.690]	[0.193]	[0.778]
Labor mobility^2 *(LM^2)*	-	0.000	-	0.000
		[0.000]		[0.000]
Competition (*C*)	-0.002 [a]	-0.081 [a]	0.016* [a]	-0.082 [a]
	[0.006]	[0.059]	[0.001]	[0.053]
Competition^2 *(C^2)*	-	-0.000***	-	-0.000*
		[0.000]		[0.000]
Gini	-	-	0.006*	0.008*
			[0.003]	[0.004]
$\bar{R}^2$	0.94	0.94	0.93	0.93
F-statistics	958.34***	686.63***	1008.37***	242.45***
AIC	391.02	385.79	1000.74	991.93
N	942	942	1,576	1,576

Notes: See Table 5.

Table 10. Robustness Tests: FDI-Spillover Effects - spillovers and industry-time dummies

	Panel J: Dummy version of spillover	Panel K: Industry-time dummies

Variable	variables			
	Linear	Curvilinear	Linear	Curvilinear
	(1)	(2)	(3)	(4)
Imitation (*I*)	1.136**	0.331	1.552*	1.711**
	[0.428]	[0.728]	[0.582]	[0.542]
Imitation^2 *(I^2)*	-	0.741	-	-1.489
		[1.267]		[1.091]
Labor mobility (*LM*)	0.393* [a]	0.246 [a]	0.159 [a]	0.136 [a]
	[0.196]	[0.695]	[0.111]	[0.795]
Labor mobility^2 *(LM^2)*	-	0.000	-	0.000
		[0.000]		[0.000]
Competition (*C*)	0.015* [a]	-0.142* [a]	0.008** [a]	-0.075* [a]
	[0.0006]	[0.066]	[0.006]	[0.039]
Competition^2 *(C^2)*	-	-0.000**	-	-0.000*
		[0.000]		[0.000]
$\bar{R}^2$	0.93	0.93	0.93	0.93
F-statistics	529.59***	214.42***	271.22***	261.88***
AIC	1009.48	662.99	749.73	734.52
N	1,576	1,576	1,576	1,576

Notes: See Table 5.

Table 11. Robustness Tests: FDI-Spillover Effects - outcome variable and estimation method

Variable	**Panel L: Value added per worker**		**Panel M: Random-effects**	
	Linear	Curvilinear	Linear	Curvilinear
	(1)	(2)	(3)	(4)
Imitation (*I*)	1.236*	1.467***	0.848***	1.048**
	[0.526]	[0.396]	[0.315]	[0.419]
Imitation^2 *(I^2)*	-	-2.444	-	-0.946
		[1.677]		[0.963]
Labor mobility (*LM*)	0.531** [a]	0.334 [a]	0.102 [a]	-0.022 [a]
	[0.202]	[0.884]	[0.147]	[0.881]
Labor mobility^2 *(LM^2)*	-	0.000 [a]	-	0.000
		[0.000]		[0.000]
Competition (*C*)	-0.117*** [a]	0.001***	0.009*** [a]	-0.063* [a]
	[0.013]	[0.0001]	[0.003]	[0.037]
Competition^2 *(C^2)*	-	-0.006*** [a]	-	-0.000**
		[0.003]		[0.000]
$\bar{R}^2$	0.85	0.87	0.93	0.93
F-statistics	1488.06***	1452.78***	8901.16***	8308.20***
AIC	1981.93	1708.71		
N	1,524	1,524	1,576	1,576

Notes: See Table 5.

Appendices

Table A1.

List of empirical studies systematically reviewed for Developing countries

Authors (year)	Country	Aggregation level	Data Timespan
Aitken and Harrison (1999)	Venezuela	Firm	1976-89
Albornoz and Kugler (2008)	Argentina	Firm	1992-2001
Aldaba and Aldaba (2012)	Philippine	Industry	1988-98
Aslanoğlu (2000)	Turkey	Industry	1993
Björk (2005)	Chile	Firm	2000
Blalock and Gertler (2008)	Indonesia	Firm	1988-96
Blalock and Gertler (2009)	Indonesia	Firm	1988-96
Blalock and Simon (2009)	Indonesia	Firm	1988-96
Blomström (1986)	Mexico	Industry	1970
Blomström and Persson (1983)	Mexico	Industry	1970
Blomström and Sjöholm (1999)	Indonesia	Firm	1991
Blomstrom and Wolff (1994)	Mexico	Industry	1970/75
Blyde *et al.* (2004)	Venezuela	Firm	1995-2000
Bouoiyour and Akhawayn (2003)	Morocco	Industry	1987-96
Bwalya (2006)	Zambia	Firm	1993-95
Castro (2012)	Chile	Firm	2001-07
Cheng (2011)	Cambodia	Firm	2005-06
Chuang and Lin (1999)	Taiwan	Firm	1991
Chudnovsky *et al.* (2008)	Argentina	Firm	1992-2001
Cuyvers *et al.* (2008)	Cambodia	Firm	2000
Erdogan (2011)	Turkey	Firm	2004-08
Feinberg and Majumdar (2001)	India	Firm	1980-94
Gachino (2010)	Kenya	Firm	1994-2001
Haddad and Harrison (1993)	Morocco	Firm	1985-89
Henning (2013)	Ten Latin America	Firm	2006-10
Jordaan (2005)	Mexico	Firm	1993
Jordaan (2008a)	Mexico	Firm	1994
Jordaan (2008b)	Mexico	Firm	1994
Jordaan (2011)	Mexico	Industry	1994
Kathuria (2000)	India	Firm	1975-89
Kathuria (2001)	India	Firm	1975-89
Kathuria (2002)	India	Firm	1989-97
Kathuria (2010)	India	Firm	1995-2005
Kee (2005)	Bangladesh	Firm	1999-2003
Kee (2013)	Bangladesh	Firm	1999-2003
Khalifah and Adam (2009)	Malaysia	Firm	2000-2004
Khawar (2003)	Mexico	Firm	1990
Kinuthia (2013)	Kenya and Malaysia	Firm	2000-05
Kohpaiboon (2006)	Thailand	Firm	1996
Kokko (1994)	Mexico	Industry	1970
Kokko (1996)	Mexico	Industry	1970
Kokko *et al.* (1996)	Uruguay	Firm	1988

Kokko *et al.* (2001)	Uruguay	Firm	1988
Kosteas (2008)	Mexico	Firm	1990
Köymen (2009)	Turkey	Firm	1990-2001
Le and Pomfret (2011)	Viet Nam	Firm	2000-06
López (2002)	Mexico	Firm	1993-99
Managi and Bwalya (2010)	Kenya, Tanzania and Zimbabwe	Firm	1993-95
Marin and Bell (2006)	Argentina	Firm	1992-96
Marin and Sasidharan (2010	India	Firm	1994-2002
Mebratie and Bedi (2013)	South Africa	Firm	2003-07
Melese and Waldkirch (2011)	Ethiopia	Firm	2002-09
Na-Allah and Muchie (2009)	South Africa	Industry	2004
Narula and Marin (2005)	Argentina	Firm	1992-2001
Nguyen (2008)	Viet Nam	Firm	2000-05
Nguyen *et al.* (2008a)	Viet Nam	Firm	2000-04
Nguyen *et al.* (2008b)	Viet Nam	Firm	2000-05
Okot (2013)	Uganda	Firm	2005-2011
Rattsø and Stokke (2003)	Thailand	Industry	1975-96
Rutaihwa (2013)	Tanzania	Firm	2007
Salim and Bloch (2009)	Indonesia	Firm	1988-2000
Sarkar and Lai (2009)	India	Firm	2002-05
Sasidharan and Ramanathan (2007)	India	Firm	1994-2002
Sjöholm (1999a)	Indonesia	Firm	1980/1991
Sjöholm (1999b)	Indonesia	Firm	1980/1991
Takii (2005)	Indonesia	Firm	1990-95
Takii (2009)	Indonesia	Firm	1990-95
Takii (2011)	Indonesia	Firm	1990-95
Taymaz and Yłlmaz (2008)	Turkey	Firm	1990-96
Todo and Miyamoto (2006)	Indonesia	Firm	1994-97
Thuy (2005)	Viet Nam	Industry	1992-99, 2000-02
Van Thanh and Hoang (2010)	Viet Nam	Firm	2003-07
Villegas-Sanchez (2009)	Mexico	Firm	1992-2001
Waldkirch and Ofosu (2010)	Ghana	Firm	1992-98

Table A2.

Testing for Sample Attrition: Probability of dropping out of the sample

Exports	-0.091

	[0.111]
Foreign-owned	-0.131
	[0.141]
Firm size	-0.115
(20-99 workers)	[0.128]
Firm size	-0.290
(100+ workers)	[0.229]
Firm age	0.001
	[0.001]
Formal training	-0.019
	[0.019]
Technological gap	0.467
	[0.424]
Capital intensity	0.031
	[0.024]
Human capital	0.000
	[0.000]
Constant	0.197
	[0.296]
N	2,586

Notes: Robust standard errors in brackets are clustered at country level. The explanatory variables are used from the 2006 survey only. The dependent variable is a dropout dummy that takes the value one if the firm is not observed in the 2014 survey and zero otherwise.

Table A3.

Definition of Dependent and Independent Variables

Variable	Description
Exports	Firm is exporting
Foreign-owned	Foreign-owned firm if foreign participation is at least 10%
Firm size (5-19 workers)	Size of the firm is Small: 5-19 workers
Firm size (20-99 workers)	Size of the firm is Medium: 20-99 workers
Firm size (100+ workers)	Size of the firm is Large: 100 workers and mote
Firm age	Firm age: number of years they have been in operation
Formal training	Formal training programs for employees
Technological gap	The ratio of average foreign productivity to domestic productivity in the same country and sector
Capital per labor	The logarithm of expenditure on Machinery, vehicles, and equipment per worker
Human capital	The total number of employees in a firm
Demonstration	Share of total sales in a given industry accounted for foreign firms
Labor mobility	The relative weight of foreign-owned firms in total employment in a sector
Competition	Price markup at firm level through the differences between firm's total sales and costs over total sales
labor productivity	Logarithm of firm annual total sales per its worker